

THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

NOVEMBER, 1889.

Thou, Lord, in the beginning hast laid the foundation of the earth, and the heavens are the works of thine hands.

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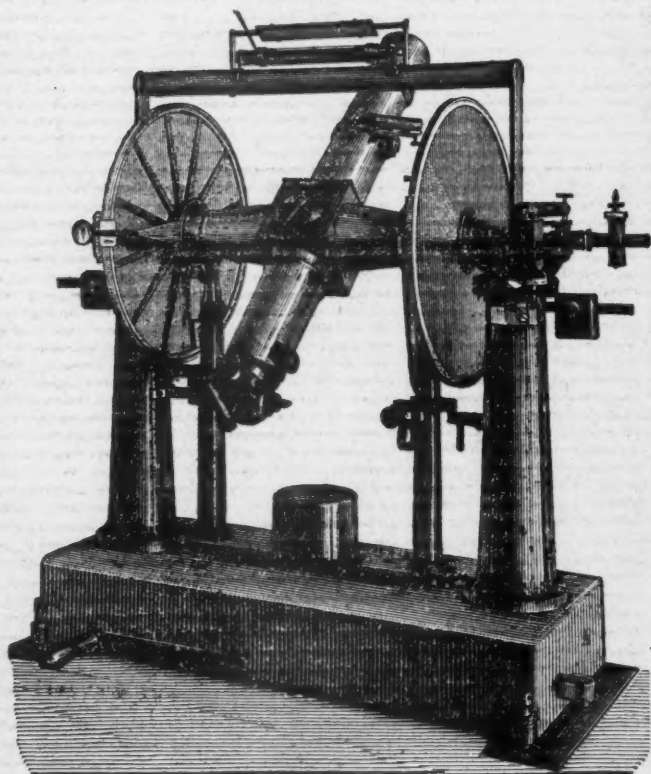
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THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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RECENT SCOTTISH METEOROLOGY COMPARED WITH SIMULTANEOUS SUN-SPOT CYCLES.

BY C. PIAZZI SMYTH.*

For THE MESSENGER.

When Professor Wm. W. Payne, in his able catering for the growing public of his "SIDEREAL MESSENGER," was pleased to honor me with a request for a compendious account of my rather over-long paper on the above subject, printed last year in the Transactions of the R. Society, Edinburgh; and to flatteringly assure me that the deductions which I brought out there would "interest readers in America, who have been giving some attention to phenomena of that kind," I felt it even a double duty, to endeavor to do what I could. For over and above all present claims and interests, I am old enough to remember the whirlwind of excitement with which, some fifty years ago, all the leading phisicists of Great Britain received *their* Colonel Reid's accounts of *your* Mr. Redfield's explanations of the West Indian hurricanes; and of the greater British storms as those huricanes' later dying efforts after traversing over nearly half the world in an orbital path of pre-ordained and regular kind. For out of such a combination of British, with American, observations, the generous sentiments of all the best of our scientist kind leaped at once in hope to the firm conclusion that meteorology so pursued had a grand future before it, and might become one of the highest, and even most cosmical, of the sciences.

Yet is it doomed to begin with local details even of the pettiest kind. And I,—having had officially such observations to the extent of many millions pass through my hands, for ordinary computation, and for furnishing out

* Late Astronomer Royal for Scotland.

government reports on the health of the people, every month, and every quarter, year after year and for upwards of thirty years,—considered it in honor incumbent upon me, before resigning in old age my national office, to put all those almost innumerable observations together on a general principle, and compare any symptoms of progress amongst them, with the course of physical phenomena in that great enlightening and necessarily ruling orb, the sun.

The only novelty here was in the particular mass of meteorological observations discussed; viz., bi-diurnal notations of some twenty different instruments on phenomena at fifty-five different stations in Scotland, throughout all the years 1856 to 1887 inclusive. For the connection of *some* mundane meteorology, as well as magnetism, with the central and most visible, though still little understood eleven year spot-cycle of the sun, had begun long before in other countries; and many names of American, English, Irish, Swiss, German and other scientists have been rendered famous forever by their labors therein, though they themselves in too many cases have now passed away.

THE FIRST EDINBURGH SUN-SPOT ENQUIRY.

Indeed, even in Edinburgh, we had had some previous experience bearing on the same question; and as touching the disagreements, as well as agreements, of those earlier Scottish labors with those of other researches at the same times, a few words may well be expended now, before coming to the later observations and dates more particularly called for in these pages.

That earlier Edinburgh essay for comparing local weather at one little point only on the earth's surface with sun-spot cycles, ruling, if at all, the entire globe, had the limitation of depending almost entirely on temperature alone; but that in a first rate manner. For, from 1836 to 1876, there were weekly observations of four grand thermometers with their bulbs sunk into the rock of the Observatory hill, at the successive depths of 3, 6, 12, and 24 feet respectively. The results, too, thence derived, were found capable of so much solidity of proof that attempts were made to connect with them the temperature observations of the air by ordinary meteorological observers, for the still earlier dates of 1821

down to 1835, or from five years before the immortal sun-spot cycle observations and discoveries of M. M. Schwabe and Wolf, to the establishment of the rock thermometers on the Edinburgh Observatory hill by the late Professor James David Forbes.

Now the first result of bringing together the Edinburgh temperatures and the mighty sun-spot cycles for those fifty years in all was, I am afraid, a disappointment to the Observatories of Greenwich and Kew, to the British Association, and many of its then living, most able, members now alas, no more; as Warren de la Rue, J. Alan Brown, General Sabine, Professor Balfour Stewart and many others,—for there was no immediate and simultaneous likeness in the curves of our thermometers and the sun-spot numbers as furnished from various acknowledged sources. (See a plate three feet long in the Transactions of R. Society, Edinburgh, Part II, Vol. xxix for 1879-1880; also the xiiiith Vol. of the Edinburgh Observations published in 1871.)

But while the eleven-year cycle of sun-spots was repeated five times clearly in those fifty-six years and still more conspicuously three times in the last thirty-four of them;—it was precisely in this latter period that the Edinburgh rock thermometers also were most emphatic in showing a cycle of the same peculiar duration, but not coinciding even in its solitary maximum with the date of any one maximum, or minimum either, of any eleven year cycle of sun-spots; but appearing some two or three years after the beginning of each new cycle of spots.

The difference might indeed have admitted of simple explanation, had it stood by itself; but it was accompanied by the further feature, that though the seasonal variations of temperature had been eliminated by calculation, yet the course of super-annual temperature, in place of a nearly uniform rise from *minimum* to *maximum*, and then a similar fall from *maximum* to *minimum*, exhibited little but series of successive undulations of short period, say from 1.5 to 3 years; and it was these, sometimes running together which raised their maxima, as well as depressed their nearest minima, beyond the average; while at other times of half period they decreased both the one and the other. Yet never so perfectly as to exhibit the true course of aerial tem-

perature (which the deep rock thermometers showed most incontestably had smote the earth from the outside, or from the heavens towards the inward terrestrial parts), as a dead level, but proved it a never ending, tumultuous motion of waves following waves.

With such varied and compound orders of interferences too, that besides four nearly eleven-year maxima, each of two or three years, duration at the central epochs of:

1834
1846
1857 and
1868

it was quite plain that the 1857 maximum of temperature rose far above the two preceding, as well as the one following maximum. Also that nothing so low as the grand minimum of the temperature curve in 1836 had been experienced in the whole fifty-six years under study. Whence all men are led anxiously to enquire, *when* is likely to take place the next equally low minimum to that of 1836, and the equally high and long-continued heat period of 1857, or concurrence of temperature undulations of a more signal and rarer kind than each and every eleven-year cycle can show? Some vague surmises had imagined that sixty-one years might be the time of a restoration of the earthly temperature: and there were lately some remarkable coincidences between 1825 and 1886, 1826 and 1887, as well as 1827 and 1888. But a great depression chronicled in 1822-23 was not repeated in 1883 and 1884; nor is it likely from the very nature of wave effects, that the practical results should run long together. Alas that the science of the world has lost that born genius for undulation mathematics, your Professor Pliny Earle Chase, of Haverford College, Pa., who seemed more fitted and inclined for such calculations than almost any other scientist of his time! But it was not to be, and in the midst of the void which his departure occasioned, I attempted to report anew on the sun-spot bearings of the observations of the Meteorological Society of Scotland from 1850 to 1887 or those exactly which Professor Payne now inquires after.

THE SECOND EDINBURGH SUN-SPOT ENQUIRY.

The period therein concerned, it will be seen, was rather short; viz., not quite three of the eleven-year cycles, and only

half the possible sixty-one-year cycle. But the value as well as the peculiarity of the occasion chiefly resided in this, that the terrestrial portion of the observations, instead of being by a single observer on one hill top, were by fifty-five observers spread all over Scotland and the Isles thereof; and instead of being confined to temperature alone, were equally directed to a large variety of physical influences; while it was still to be proved by practical test, which of those several observable quantities might be more immediately in touch with sun-spot variations.

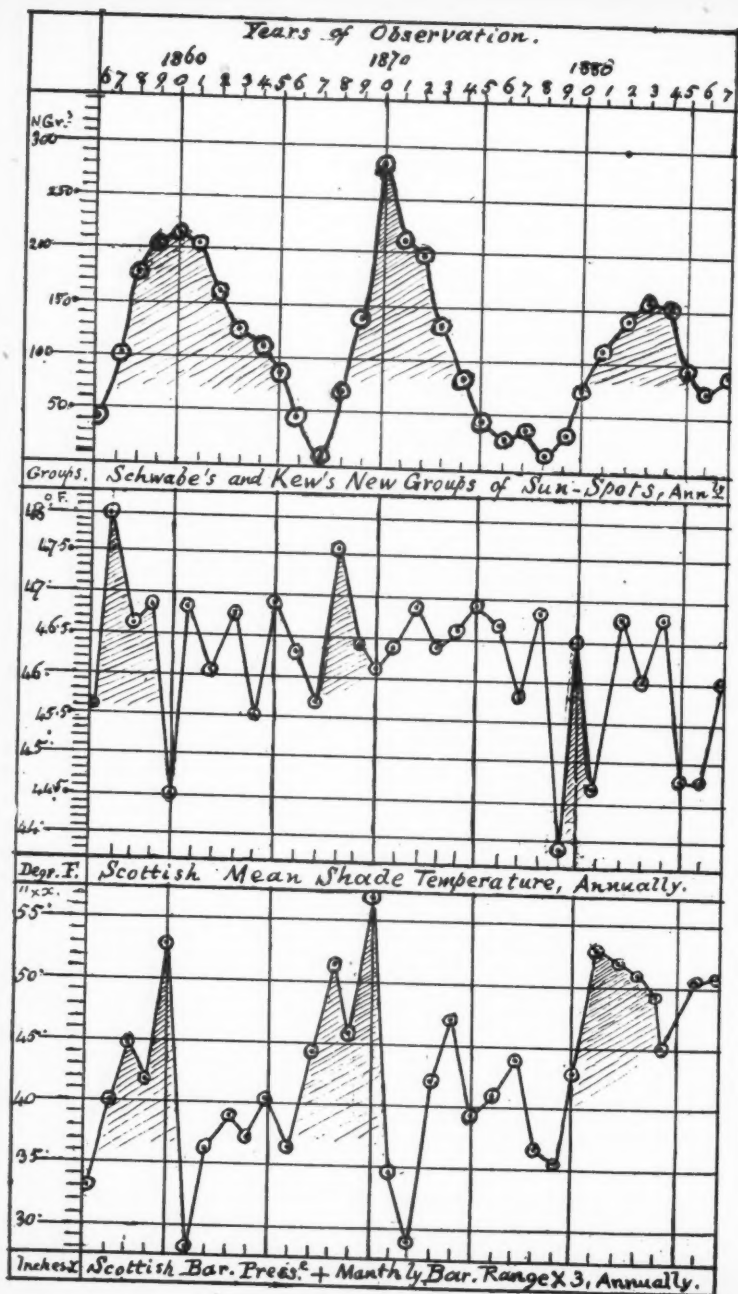
At the time, indeed, of beginning this second enquiry in Edinburgh, I was informed by high authority that the sun-spots had lost their influence, and that no one believed in them now as affecting the weather.

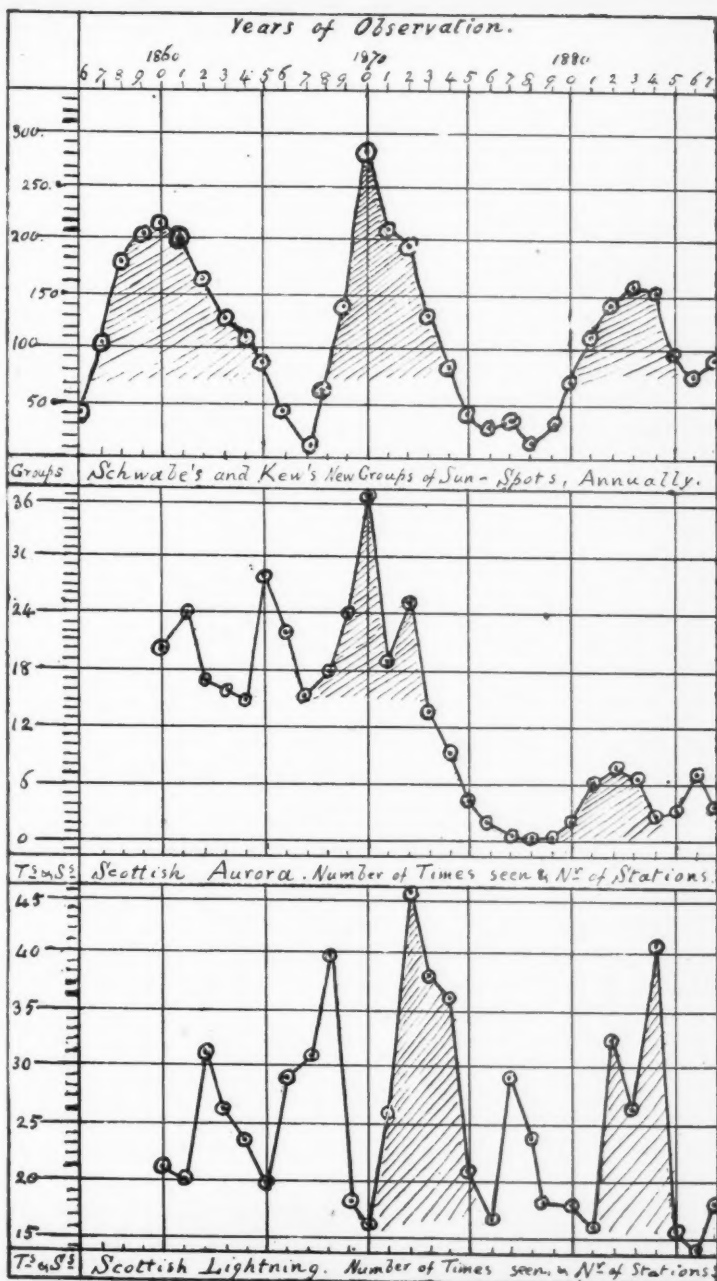
But the undulation idea given by the earlier enquiry, led me to take more note of the *difference* of one sun-spot cycle from another. Whence it immediately appeared that while the cycle from 1856 to 1867 had been a more than fairly ordinary one; that from 1867 to 1878 had been one of acute confluences; while that from 1878 to 1887 (probably to end in 1890) had been one of a miserably weak beginning; much disturbed too, as well as depressed, throughout. And an idea of the extent to which these differences were carried by nature, and established by observation, may be described thus,—

Every sun-spot cycle yet chronicled has the front of its undulation steeper than the rear; testifying to the greater energy of the solar radiations in that earlier part of the cycle; or when there is, *mirabile dictu*, more nearly a minimum than a maximum of visible sun-spot area.

And every cycle similarly recorded, testifies also to the occurrence of another, though smaller, outburst of energy in the course of the longer dying out of the principal wave; sometimes single as in our first, and probably in the third eleven-year wave; sometimes double as in the second.

But while the first of these three particular waves has nearly the normal steepness of front, viz.: 4 years of rise to 7 years of fall, and a maximum height of 220 new spot groups; the second of our three waves rushes up in the short period of only three years, and then to the unparalleled height of 280 groups, but takes 8 years to decline





therefrom. While the third wave is feeble and sluggish beyond example, employing $5\frac{1}{2}$ years to rise slowly to its maximum, and that a poor one of only 160 groups.

No distinct and equal recurrence, therefore, was to be expected in the weather of each of those three eleven-year periods; but there might be sufficient difference in the sun-spot elements to establish a dependent difference in the earthly simultaneous experiences.

To this end the sun-spot numbers, as collected at Kew Observatory since Mr. Schwabe's death, were projected on a uniform scale for each year concerned; while underneath, for the same years, were projected the mean annual results of 23 different kinds of meteorological observations, as thus,—

(1). Barometric pressure. (2). Monthly range of above. (3). Mean temperature in shade. (4). Daily range of shade temperature. (5). Black bulb thermometer by day. (6). Black bulb by night. (7). Humidity. (8). Elastic force of vapor. (9). Days of rain-fall. (10). Annual depth of rain. (11). Strength of wind. (12). Days of north wind. (13). Days of east wind. (14). Days of south wind. (15). Days of west wind. (16). Hours of sunshine. (17). Daily percentage of cloud. (18). Aurora, amount and extent. (19). Lightning, amount and extent. (20). Mean maxima of shade temperature. (21). Mean minima of shade temperature. (22). Elevation above freezing point. (23). Depression below freezing point.

TEMPERATURE CONNECTIONS AGAIN.

On looking over all these plates it was easy enough to recognize the chief temperature characteristics of the earlier enquiry coming out again, though in degree, and more disturbed by rapid undulations than the older deep-sunk thermometers. Also that the chief manifestations of terrestrial air-temperature were by no means simultaneous with the greatest tabulated areas of sun-spots; but were, on the contrary, singularly coincident with something that rapidly took place in the sun, during the first or second year only, or near the very beginning of each new eleven-year cycle of spot-making and growing; and testifying to a violent variation of the solar radiating energy then taking place.

But this great excess of heat, which chiefly took place in 1857 and the times of our first cycle, did not prevent its being followed by an almost equally marked depression of temperature in 1860. And if the maximum temperature of the second cycle in 1868 was a small one, so was also the

following minimum. While in the third cycle the maximum heat undulation, while still visible at the important epoch for starting a new set of undulations, viz., 1.5 years after the sun-spot maximum, was almost lost and swallowed up between two of the deepest temperature *depressions* on either side of it.

In short, all the earth-felt but sun-derived temperature—(and derived, not from accumulated “spotted area” of the sun’s surface so carefully observed by certain astronomers, but from some invisible radiation at the time of almost minimum of spots, said spots themselves being further shown by spectroscopy to be a cooler region than the rest of the sun’s photosphere)—was on a long-continued down-grade, extending and felt more or less through all the three eleven-year cycles, or whole period of thirty-two years. Not, however, bespeaking thereby, or proving a dying out of the sun’s heat, sensible in so short a space of time; but merely indicating the approach of a minimum of long period, like that of 1836; and afterwards a rise like that of 1857. See our first Plate, its top horizontal compartment representing the three crucial sun-spot cycles between 1856 and 1887, and its second compartment representing the mean shade temperature of Scotland for the same years.

BAROMETRIC CONNECTIONS.

The next most remarkable dependence on a new sun-spot eleven-year cycle’s beginning, but occurring rather later, or more nearly with the growth of spotted sun area, than the temperature shock,—say in the years 1860, 1870 and 1881, instead of 1857, 1868, 1880,—is found *first* in the projection of barometric pressure, and *then* and still more remarkably, in that of the monthly range of that same kind of pressure.

Now this is an important double result to have arrived at because the barometer is the most accurate, far-reaching and trustworthy instrument which meteorologists possess. It is one, too, with which it is almost impossible to make a bad observation for absolute height; while for variation, or range of height in the course of a month, no prejudice can well exist in the mind of the observer; and the numbers chronicled, refer to something in the air invisible to the eye

impreceptible to the feelings and yet allowed by scientists to be at the base and root of all meteorology. But for testimony of the now proved concurrence of a certain kind between the barometric and the eleven-year cycle of sun-spots, please to look again at our first Plate, where the third and lowest compartment represents barometric pressure combined with three times its value of the monthly range thereof, and greatly varying with each of those three diverse and yet related cycles of solar appearances turned towards the earth.

In fact the variations *inter se* of three sun-spot cycles, which cover the duration of all the Scottish Meteorological Society's observations discussed at the R. Observatory, Edinburgh, are a most fortunate differential feature to assist in the present investigation; and we have not to go much further in our research before alighting on another meteorological curve which intensifies, while it exactly synchronizes with the excess and acuteness of the energy outburst displayed in the second sun-spot cycle's curve, extending from 1867 to 1878; and equally confirms the deplorable want of energy at the right time revealed in the third one.

AURORAL AND WIND CONNECTIONS.

This singularly confirming curve is that of aurora, its frequency and extent; or the number of times seen, and the number of stations reporting it each time. And if the first of the three sun-spot cycles is not very conspicuously marked with aurora, it is largely due to the want of a sufficient number of trained observers at that beginning of the Scottish Meteorological Society's activities, so that neither aurora nor lightning were observed during the beginning of the first cycle, say 1857 to 1860, though very steadily ever afterwards.

Further the "strength of the wind" curve, responds sensibly, though inversely to the auroral curve. So that during years of abundant auroral display, the winds were moderate in force or velocity, and chiefly from the west. But when Auroras left us in darkness on moonless nights, the winds became more violent, and verged to east and north, as testified by their curves for "Direction."

LIGHTNING'S CONNECTION WITH AURORA AND SUN-SPOTS IF
TIME BE ALLOWED.

But there is a more accentuated connection still with Aurora, though by opposition, in the lightning curve, observed in the same manner as the aurora. For the very maximum demonstration of Aurora is exactly coincident in time, with the very minimum of lightning, and *vice versa*; but with the curious feature of the lightning's variation taking place *directly*, so nearly two years after the variations of the Aurora, that if the latter are combined with the lightning returns two years before they took place (or as if Aurora, once emitted into the terrestrial atmosphere, requires two years before it is changed into lightning), the original Aurora curve has all its chief features remarkably intensified; especially its acute rise in 1870, coincidently with the similar feature of the second sun-spot cycle.

For the pure and simple curves, however, of Aurora first, and then lightning, please to see our Plate 2, its horizontal sections two and three from the top. And if you should further ask why we have not of late been having any of those magnificent displays of Aurora which were so frequent in 1869, '70, '71 and the beginning of '72, the want of spot-forming energy in the present (or the third) sun-spot cycle is the nearest phenomenon to the real cause which can be quoted from crude observation.

CLOVA, RIPON, ENGLAND, August 15, 1889.

METEORS AND METEORITES.

W. H. S. MONCK.

FOR THE MESSENGER.

The promulgation of Mr. Norman Lockyer's theory of the origin of the stars has caused astronomers to devote more attention to the subject of meteors and meteorites. I do not propose to discuss this theory in the present article, but only to give a short summary of what is known on the subject.

By *meteorites* I mean solid bodies which have fallen to the earth, whatever their origin may be; by *meteors*, the shooting stars that flash for a few moments in our night sky and

then vanish. To one or other of these heads what are termed *aerolites*, fire-balls, *bolides*, etc., may be referred. The term, fire-ball, for instance, is usually applied to a meteor of unusual magnitude and brilliancy. Mr. Lockyer's spectroscopic observations were made with *meteorites* as thus explained. Konkoly and a few others have endeavored to analyze the spectra of *meteors*, but the task is one of great difficulty. The first question to be considered is: Are meteorites merely meteors which from some cause have escaped dissipation in the atmosphere, or are they bodies of a different origin?

There is a good deal to be said on both sides of this question. On the one hand it is urged that meteors as a rule are dissipated at great heights in the atmosphere, having been intensely heated before dissipation; whereas meteorites were not only in the solid condition when they fell, but did not appear to be very highly heated—some apparently not being even red hot. As the heating is due to the resistance of the atmosphere which is greatest in the dense regions near the earth, this remarkable difference in the temperature of meteors and meteorites points to a difference of velocity so great as to suggest a different origin.

Again it is urged that no meteorite has been connected with any of the great meteor-showers recognized by observers,—especially with those in which the velocity of the moving meteors is known. Finally, meteorites exhibit traces of volcanic origin, and seldom, if ever, exhibit any chemical constituents which are not found on the earth; and if we suppose terrestrial volcanoes to have been more powerful in past ages (and considering the height to which the Krakatoa dust ascended, and the time which it remained suspended in the air the difference may not be very great), the stones shot from these volcanoes would revolve in orbits intersecting the earth's orbit, with velocities little different from that of the earth. On the other hand it may be said that some meteorites appear to have been highly heated when they fell; that some have been connected to a high degree of probability with well-known meteor-showers; that some meteors, especially fire-balls, have been dissipated at comparatively small heights; that the fall of meteorites has often been preceded by detonation, and detonations are quite common

in the case of large meteors which approach pretty near the earth before dissipation, though their velocity is evidently considerable and their heat intense; with other similar reasons. One of the latest meteorites (known as the Mazapil meteorite) favors the latter theory. It was evidently very highly heated when it fell, and there are strong reasons for identifying it with the well-known meteor shower which follows in the track of Biela's comet. It is worth mentioning, however, that the Bielan meteors are about the slowest of known meteor-showers, while the Mazapil meteorite was one of the most highly heated of meteorites.

Should the late Mr. Proctor's theory of the ejection of comets and meteors, not only from the stars, but from the sun and planets (when in the sun-like state), be finally accepted, it will go far towards reconciling these conflicting views. Meteors and meteorites will then belong to the same class, but as earth-born or planet-born meteors are likely to be moving with less velocity than star-born meteors, they are more likely to fall to the earth in the solid form as meteorites. The chemical composition of a meteor will, according to this view, depend on the chemical composition of the body from which it was ejected, and there is some risk in drawing general conclusions from either the chemical composition or the spectra of meteorites unless we know from whence they came. The Mazapil meteorite would be an interesting one to experiment upon from our comparative certainty as to its origin; but even then the question remains whether Biela's comet was an original member of the solar system (ejected from Jupiter as Mr. Proctor thought), or a wanderer from space which Jupiter captured.

With respect to meteors it is well known that they appeared to come in showers emanating from particular radiant points, which, allowing for the effects of perspective, means that they come to us from the same direction, just as the clouds usually appear to diverge from one point on the horizon and converge to the opposite point. As to their motion being in right lines the very small portion of the path which we see them describe could hardly exhibit the curvature of the real orbit. If observers at two distant places observe the points where the meteor appears and disappears its height above the earth at appearance and disap-

pearance can be computed (assuming the points to be the same). When it is vaporized or dissipated in the atmosphere the points of disappearance are almost certainly identical, but as to the point of first appearance there must always be some uncertainty. If the duration of the flight is also observed we can compute the velocity, but here again there are considerable chances of error. The radiant point of a shower is found by tracing the paths of the meteors on a globe or map and finding the points of intersection. But of course every point where the paths of two meteors meet is not a radiant. It is only when the paths of several meteors pass through a point that a radiant can be positively assigned. They seldom however pass exactly through a point and the radiants determined by different observers for the same shower often differ. Nevertheless the coincidence is sufficiently close to show that a large number of meteors frequently come to us very nearly in the same direction and thus belong to a common system.

Enormous velocities indicating strongly hyperbolic orbits were formerly assigned to some meteors or fire-balls, but since observations have been made with greater care such velocities have been rarely, if ever, observed. An important step was subsequently taken by observing that certain meteors followed in the track of certain comets and, in some instances, at least, exhibited the same periodicity as the comet itself. The best known instance is that of the November Leonid meteors which follow the track of the comet of 1866 and attain a maximum every thirty-three or thirty-four years, that being also the period of the comet. These meteors have a very high velocity in the air (not less than forty-four miles per second) because the motion of the comet is retrograde and the inclination of the orbit not being large, the earth and the meteor-shower are moving very nearly in opposite directions at the time of their encounter. Hence this grandest of meteor-showers has not been known to produce a single meteorite. There is, however, a second November meteor-shower more favorably situated for that purpose. It follows the track of Biela's comet whose motion is direct and inclination small, so that the velocity of the meteors is only about one-fourth of that of the Leonids. It is to this shower that the Mazapil met-

corite probably belonged. Two other known meteor-showers have been in like manner connected with comets,—the Lyrids of April, and the Perseids of August. Any other identifications hitherto made must be regarded as very doubtful.

How are these meteors related to the corresponding comets? As yet we do not know. It is to be observed, moreover, that in speaking of them as following the tracks of comets we are not quite correct. If they followed the *exact* track of the comet they could never enter the atmosphere at all, for the nearest point of the comet's orbit lies at a considerable distance from the earth. What really occurs is that when the earth is making its nearest approach to the comet's orbit we see a number of meteors whose motion is nearly parallel to that of the comet when at the same part of its orbit. In some cases, too, these meteors exhibit a periodicity agreeing with that of the comet. But the August Perseids return every year with apparently but little change in the richness of the shower, so that the meteors must be scattered all along the path of the comet; while even when meteor-showers are periodic they usually appear in considerable numbers for two years in succession and in diminished numbers for some years before and after. Moreover, even when densest, they are at a considerable distance from the comet. The Perseids exhibit another peculiarity; they appear a considerable time before the earth reaches the node of the comet's orbit and continue for some time after the node has been passed. A possible explanation of this fact is afforded by the discovery of Dr. Hock that there are families of comets—comets having a similar origin and to a large extent similar orbits. The Perseid meteors are perhaps attached, not to the single comet with which they are usually associated, but to a family of comets of which it is a member.

It would be rash to conclude from what we know at present that comets consist of collections of meteors. The meteors rather appear, as a rule, to *follow* the comet; and, as has been seen, to follow it in a somewhat different path. As yet, however, no meteor-comet is known to have passed the node nearly at the same time that the earth did so; whenever this occurs we shall be in a better position to de-

cide the question. It seems, however, equally probable that comet-meteors are formed by the condensation of comets' tails, a fact which would account for their divergence from the track of the comet to which we owe their visibility. The ascertained fact is simply that four known periodical comets are followed by meteor-showers in which the meteors are moving nearly (but not exactly) in the path of the comet.

It is remarkable that so few comets have hitherto been connected with showers of meteors. But it should be borne in mind that, in numerous instances, the comet is so distant from the earth at its nearest approach, that a meteor attached to it would be very unlikely to enter the atmosphere. A further difficulty in the comet theory is that a number of well known meteor-showers do not appear to be connected with any known comet. There is however reason to think that comets are liable to dissipation (a fate which seems to have overtaken Biela's comet) in which case the meteor train might continue after the corresponding comet had disappeared. Again, if Mr. Proctor's theory of the origin of comets in ejection should prove correct, it is evident that not only might meteors be ejected nearly in the path of a comet by a subsequent outburst of activity, but that meteors might be ejected in eruptions where the conditions for ejecting a comet were not realized. Our great terrestrial volcanoes eject clouds of steam (probably not unmixed with other gases or vapors) as well as stones. The comet may perhaps be assimilated to the vapor-ejection and the meteors to the stone-ejection; and under particular circumstances stones may be ejected with little or no vapor or *vice-versa*. It thus becomes doubtful whether we should go outside of the solar system for the origin of any of the meteor-showers which we have been considering. The Bielan meteors may have their origin in Jupiter, the Leonids in Uranus, and August Perseids in Neptune; but for the April Lyrids an ultra-Neptunian planet seems requisite. The existence of such a planet, however, is not improbable on other grounds.

It is therefore doubtful whether meteorites can give us any information (otherwise than by analogy) as to what goes on beyond the limits of the solar system. No doubt if we could be certain that a meteorite which had fallen to the

earth was a visitor not only to us but to the solar system both its chemical analysis and experiments on its light would have very great interest. But unfortunately a body is not likely to reach the earth in the solid form if its velocity is considerably different from that of the earth, and where the difference in velocity is not great it is pretty certain that the falling body is now a member of the solar system whatever its origin may have been. To obtain certain information as to anything beyond the solar system from meteors, we should require to examine the spectra of some of those whose velocity proved that they were visitors from external space, and I doubt if even Konkoly has effected this. Reasoning from analogy it seems very unlikely that meteors exist nowhere except in the solar system, but it does not follow that meteors outside of our system possess all the same properties, or the same chemical composition as those within it.

One very important question in connection with this subject is raised by Mr. Denning's discovery (or theory) of meteors with fixed or stationary radiants. That Mr. Denning observed the meteors in question cannot, I think, be disputed; nor are his radiants open to much doubt. The real question is whether the meteors observed by him belonged to the same meteor-flight or not. Comparing the results of different observers it would seem that there is an uncertainty of probably some degrees in determining the radiant-point of a given meteor-shower; and therefore, if a shower on the 15th of April and another on the 15th of May were recorded as having the same radiant, the radiants might still be really different. If the shower continued during the whole of the intervening period the chances against such an explanation would be considerable, but if it was intermittent the probability of dealing with two really distinct showers would be increased. Everything depends on the number of meteors observed, the accuracy of the observations, and the question whether they appear to be spread evenly over the period of continuance or collected in clusters at particular points of time. Mr. Denning's observations, however, have been partially confirmed by others, while no one has arrived at a contrary result by observation; and when his well-known skill and practice are taken into con-

sideration the chances are decidedly in favor of the existence of meteors with fixed or stationary radiant points, however they are to be accounted for. Their existence, or apparent existence, at all events deserves a high place among the unsolved problems of meteoric astronomy.

The late Mr. Proctor explained the existence of such meteors by supposing their velocity to be so great that the changes in the earth's motion produced very little effect on their apparent direction. Mr. Denning is decidedly of opinion that they do not move with this astonishing velocity, and, in fact, from the duration of visibility, etc., it is certain that they cannot do so unless the atmosphere extends to a much greater height than has hitherto been supposed. Mr. Denning, moreover, refers to some doubly observed meteors belonging to the stationary-radiant class whose height was by no means so great as Mr. Proctor supposed. I ventured to suggest that these meteors had already been so impressed by the motion of the air, when they first became visible, that they appeared to a terrestrial observer to be moving in their original direction—the actual displacement of the meteor by the air exactly balancing the apparent displacement, (supposing that it had pursued its original path) due to the spectator's motion. This explanation is not very satisfactory, but I know of no better, assuming that the meteors in question really belong to the same group or cluster; while if they do not, no rational explanation has hitherto been given of the apparent constancy of the radiant-point during a considerable period of time.

The question whether meteors belong to the solar system, or are visitors from external space, or whether each supplies its quota, is still, I think, unsolved. But if any of them originate within the solar system this is probably true of meteorites or bodies which fall to the earth in the solid form, their escape from dissipation in the air being due to the very moderate velocity of their motions relative to the earth. For this reason I think we are never likely to meet with a meteorite of which we can assert positively that it once existed outside the limits of the solar system. At all events we cannot affirm this of any known meteorite.

THE SOLAR ORIGIN OF THE AURORA.

M. A. VEEDER.

FOR THE MESSENGER.

The identification of the precise solar condition upon which auroras and their attendant magnetic storms depend, requires that an account shall be made of all the facts known in regard to these phenomena, and that any conclusions adopted shall be consistent with these facts. The following article is a synopsis of the results of observations during a series of years bearing upon various phases of the subject, and justifying, it is thought, certain conclusions in regard to the origin of the aurora that are worthy of note.

It has long been known that auroras and magnetic storms increase and diminish in like ratio with each other, and also in proportion to the spottedness of the sun. When, however, an attempt is made to go further than this and study these phenomena in detail from day to day, instead of by a system of averaging through extended periods, serious difficulties are encountered. Very often for days together spots are numerous upon the sun, and yet there is no aurora and no extraordinary variation of magnetic declination. Likewise, on the other hand, fine auroras are not unfrequently seen when the sun is absolutely devoid of dark spots. The problem is to explain, if possible, this apparent anomaly.

It requires but little observation to show that something else upon the sun beside the dark spots is concerned in the production of magnetic phenomena, which often occur in the absence of such spots. We are compelled to extend our investigations further, and inquire as to the part performed by the eruptions of glowing vapors known as the faculæ. Here, as will appear in the course of the discussion, the results of such study are more satisfactory than in the case of the spots. Carrington's famous observation in 1859 in regard to an outbreak upon the sun, which was coincident with a magnetic storm and aurora, certainly had reference to a facular disturbance. Professor C. A. Young, in his treatise upon the sun, at page 157 describes another instance of similar character, the disturbance in that case also being facular, although followed by a spot appearing by rotation. Aside from these two instances nothing has been published

having sufficient precision to be worthy of notice. In any event it is evident that the faculæ must be taken into the account. Inasmuch as the faculæ and spots vary in like ratio during any given period of sufficient extent, although not coincidently, the one group of phenomena following the other at an interval of days and sometimes weeks, a portion, at least, of our anomaly has been explained, namely, the occasional outbreak of auroras and magnetic storms at times when there are no dark spots upon the sun. Thus avoiding one difficulty we have, however, increased another. The sun is often free from dark spots, but is scarcely ever free from well defined groups of faculæ. Accordingly we might suppose that auroras ought to continue all the while.

We may relieve a portion of the difficulty at this point by studying the history at each return of disturbances that persist through successive revolutions. Through comparisons thus made it becomes apparent that all solar disturbances have not the power of originating magnetic phenomena in equal degree. Often those that are comparatively insignificant in appearance nevertheless are very active in this respect. But, even in the case of those that are most active and persistent, we find that auroras and magnetic storms do not continue throughout each transit which they make across the earthward side of the sun. On the contrary auroras and their associated magnetic perturbations are for the most part of comparatively limited duration.

At a single station in the United States, as a rule, the aurora is seen for but one night at a time, no matter how brilliant it may have been. Usually, however, at each manifestation it is reported from different stations for about four days. Magnetic storms also die out in about the same length of time. It must be the fact, therefore, that solar disturbances have the power of producing magnetic phenomena during a very limited portion only of their transit across the earthward side of the sun, and this, too, in spite of the fact that they may remain equally active from day to day, there being no evidence of any decided variation in the eruptive forces.

Another curious feature in connection with the behavior of the aurora that is inconsistent with the idea that its brevity

of duration is due to sudden variations in the explosive forces, is its not infrequent regularity of recurrence at intervals closely approximating the time of the revolution of the sun. Thus the finest auroras of recent years have appeared in more or less extended series twenty-six or twenty-seven days apart. During the spring and summer of 1886 there was a succession of magnificent auroras at very nearly this interval from each other, the dates of maximum display being April 14, May 8-9, June 3-4, June 29-30, July 26 and August 23. During the winter and spring of 1887 there was a remarkable double series, the dates of maximum display of one portion being February 9, March 7, April 2-3, April 30, and May 27, the other half of the series following at regular intervals upon dates eight days later than those above given. The same periodicity is very common in connection with smaller displays and may be readily shown by counting the number of stations daily reporting auroras in the Monthly Weather Review of the Signal Service and constructing curves. It is inconceivable that such regularity of recurrence can be due to explosive forces alone. It looks very much as though the rotation of the sun on his axis must be concerned. This being the case we need only to identify the particular portion of each transit in which disturbances have the power of producing auroras.

Here, again, we may receive aid from studying the behavior of auroras. As a rule they burst forth suddenly, being most widely extended at the outset and becoming fainter, and being seen only at isolated stations subsequently. Such behavior is inconsistent with the idea that solar disturbances originate auroras as they approach the sun's meridian, in which case there would necessarily be a gradual instead of an abrupt increase. There can be but one point in the transit at which abruptness of beginning can be satisfactorily accounted for, and that is at the eastern limb.

Instituting observations and keeping a record in reference to this point it is found that there is a preponderating weight of evidence in favor of the conclusion that solar disturbances originate auroras, when at the sun's eastern edge appearing by rotation. At times it has seemed as though outbreaks located elsewhere upon the sun's disc had been concerned, but by comparing the record during successive

revolutions it has become apparent in many such cases that some small dot of faculæ at the eastern edge was really responsible; this mere dot at other returns developing into a disturbed area of vast extent, and being attended at each appearance for months by an outbreak of magnetic phenomena. Pursuing this method, and judging as to the activity of disturbances by their history as well as their appearance, it has been found that there is a remarkable coincidence between the occurrence of auroras and the location of disturbances at the eastern limb.

During the three years from April, 1886, to April, 1889, there were one hundred and eighty-eight well defined outbreaks of the aurora in the United States. In connection with one hundred and sixty-two of these, observation of the sun was secured, and in every case a disturbance was found upon the sun's eastern edge, small, it is true, in some instances, but larger at other returns, so as to be unmistakable. There were also twenty-two other instances in which outbreaks appeared by rotation upon the sun, no aurora being reported within the borders of the United States. It is possible, however, that the aurora was visible at more northerly latitudes. A curious feature noted in these cases especially, as well as in some others, was a manifest increase in thunder-storms as though they had taken the place of the aurora.

From these considerations it follows that disturbances at certain points, upon the sun's surface for months together, have the power of originating magnetic phenomena when appearing by rotation at the sun's eastern edge. It certainly is very remarkable that these impulses should be conveyed along lines tangent to the sun's surface. It looks almost as though something had been whirled off into space from the sun, the earth remaining within range for a limited period only.

Finally it may be remarked that the magnetic storms associated with auroras have very similar characteristics as respects brevity, periodicity and abruptness of beginning. Evidence in respect to such storms is specially important in connection with these studies because the self recording instruments are not affected by the weather, the negligence of observers, and the like, as is the case in regard to auroras.

LYONS, N. Y., Oct. 7th, 1889.

THE STUDY OF ASTRONOMY.*

In the introductory part of this article we were speaking of Young's *General Astronomy* as a desirable book with which to begin the study of astronomy. We then promised that later something would be said of the manner of its use to obtain best results in laying a good foundation for education in astronomical science. We know how difficult it is to give direction, in writing, for detailed study in any science, and that some able scholars say that such a thing is wholly impracticable; yet it is believed that the essential points in any line of study may be stated, properly related and emphasized in such a way that the inexperienced student may receive help when and where most needed. With this thought in mind to guide, we open this new text-book and notice some of its prominent topics by way of illustration.

The "Doctrine of the Sphere" is properly first in order. An accurate and a complete idea of the celestial sphere is all-important. The author suggests two ways by which the mental picture of it may be made definite. Either seems equally good for the end in view, and will serve the purpose if pondered and sufficiently applied. In working out the general idea of the celestial sphere, the student needs a celestial globe or a wire sphere so constructed as to represent all its principal parts, for the sake of applying definitions and thereby testing the statements made by the author. This kind of exercise will tend to fix facts in mind and lead to an exercise of judgment that will prove, in time, very serviceable as a habit of thought and clear expression. The need of a globe or a wire sphere to connect the statements of an author with the imaginary lines and points in the sky, to which he ought constantly to refer, is also very essential. A powerful imagination will not be able to hold all the details of this great science in mind and properly relate them and make a lasting memory picture of them, without some judicious helps like these or others that might be named. The order then is to understand and memorize the definitions pertaining to the celestial sphere, illustrate the same by suitable apparatus of home contrivance, or better, if it

* Continued from p. 313.

can be afforded, and then transfer the knowledge thus gained to the sky, and familiarize the mind with it there, in place, so thoroughly that reference to it may always be ready, easy, and definite. The student who is self-guided in study will be likely to underestimate the value and need of all this work at the outset, and will probably soon become impatient and be tempted to slight the work here and there in seemingly unimportant particulars, because he does not wish to waste valuable time in acquiring details of so little apparent value. Right here let a word of warning be given. Such thoughts about the mastery of details in a chosen pursuit ought never to be entertained by the student for one moment. If they are yielded to it means later either damaging delay in possible progress, or utter defeat after a series of weak attempts that convince him that he never had any talent for astronomical studies whether that is really the fact or not. After considerable experience in guiding students in higher mathematical studies, it is our plain conviction that more persons of good natural powers fail of high attainment in such studies by lack of thorough mastery of elemental principles and facility in their application than from any other cause. If these words shall stimulate any to do better work in early study and to take the necessary time for it, their purpose will have been served.

After the idea of the celestial sphere as a whole is gained, its motions ought next to be clearly comprehended and all the terms used in describing them. In this the globe or sphere will be very serviceable, not only in showing what motions belong to important parts of the celestial sphere, but also to give ideas of their direction and their relative velocities.

"Astronomical Instruments" is the next general theme which this text-book offers for study, and a few of the more common and important ones are described.

The first question that may well be asked by a student about a telescope, for example, is concerning the principles on which it works. How does the telescope help the observer? Briefly, it is answered that the instrument (1) has light gathering power; (2) it magnifies objects, and (3) it has a measuring apparatus which will fully use all the gathered light in determining the places and dimensions of

magnified celestial objects. How the working parts of the telescope unitedly accomplish these objects should be thoroughly understood. A small telescope should be in the hands of the student, if possible, that the parts may be examined and tried separately and unitedly. There is no picture or illustration that will at all take the place of the instrument itself. Better sacrifice a cheap spy-glass, if necessary, in order to understand the principles of the instrument, in order to gain this desirable personal knowledge. The theories of all the parts of all common telescopes are admirably set out in Young's Astronomy, and if the student will only apply the knowledge there given until he knows it for himself, opportunities to use such knowledge will rapidly multiply.

In regard to an elemental knowledge of all the instruments described in the second chapter of this book, three things may be learned definitely:

(1). What are the working parts of each instrument? (2). What work is done by each, and (3) exactly how is that work done? A plan in study of this kind presents finished steps of progress, to which the student may add as much as he pleases, without confusion if full or detailed study is later undertaken.

Chapter third offers another interesting step in our progress. It is now known what work astronomical instruments will do, but the results obtained need to be corrected before they can be related to other work properly. The dip of the horizon, parallax, semi-diameter and refraction give the apparent places, where generally the true places of celestial objects are wanted. Now the student will need to use his knowledge of geometry and algebra. The principles called for in these branches, for this work, are simple enough; but the danger is that the average student will fail to apply them independently and thoroughly enough to fix in mind either methods or essential facts. For example take the author's interesting statement concerning the dip of the horizon, that *the square root of the elevation of the eye (in feet) gives the dip in minutes*, and that this value is about one-twentieth too large, as compared with the exact formula. The student may well ask himself what is the use of giving this approximate formula when it is known to be in-

accurate, and especially to make it prominent in the text by the side of the rigorous one. This important query ought not to be answered too briefly for the student needs to be instructed right here, and be put on his guard against falling into wrong notions regarding standards of accuracy in text-books and astronomical work in general. The author has covered this point nicely and well as he usually does those that are likely to perplex the accurate and the conscientious student. He has worked out the approximate formula by a very neat use of the principles of algebra and trigonometry, which show plainly what is meant by the use of the word "approximate," and wherein the real difference between the two formulæ lies. This is useful knowledge to the beginner, because he is always so unwilling to substitute approximate work or results for those which he has proved to be rigorously true. When he is asked to do this he often thinks that he has lost something of truth by so doing, if he does not believe the results uncertain or worthless because obtained by methods known to be defective. On the contrary he ought to see that he has actually lost nothing by his chosen method of work, but rather gained by it in every useful and important particular. Another valuable lesson is drawn from this illustration which we desire also to emphasize, and that is the care which the author has taken to show the student how to pass from the general units of measure in the exact formula, to those of various concrete kinds, as radians, minutes, etc., found in the working forms of the approximate formula. We have known good students in pure mathematics to stumble badly and frequently, and with reason, because they generally have so little exercise in the change of units in ordinary elementary study. Applying these thoughts to the formulæ for parallax, refraction, and height of the atmosphere, the student will certainly have new interest in the themes themselves as well as the mathematical instrument of investigation which he has been using to measure them.

In this connection and at the end of our space for this study at this time, we give a list of errors already noticed in second issue of this text-book, kindly furnished us for publication by Professor Young only a short time ago:

Errata in the Second Issue of Young's General Astronomy.

1. P. 133; line 8 from top: for γ Draconis read α Draconis.
2. P. 190; line 1 from top: for *southern* read *northern*: for *northern* read *southern*: also add to the sentence the words, *as seen by an observer on the earth*.
3. P. 232; lines 13 and 14 from top: for $12^{\circ} 5'$ read $12^{\circ} 15'$.
4. P. 234; line 8 from top: for 1886 read 1884.
5. P. 234; line 11 from top: for $\frac{1}{400000}$ read $\frac{1}{1400000}$.
6. P. 234; line 21 from top: for *Moon's shadow* read *Earth's shadow*.
7. P. 311; article 520: substitute the following: "Since there are five independent co-efficients in the general equation (in space) of a conic having a given focus (*viz.*, the sun), it is necessary to have five conditions in order to determine them. Three are given by the observations themselves, *viz.*, the *directions* of the body as seen from the earth at three given instants; a fourth is supplied by the 'law of equal areas,' since the sectors formed by the radii vectores must be proportional to the elapsed times; and finally the fifth depends upon the requirement that the changes in the speed of the body between the observations must correspond to the variations in the length of the radius vector according to the known intensity of the solar attraction."
8. P. 314; line 3 from bottom: for *of the periods of the major axes* read *the periods and of the major axes*.
9. P. 318; line 12 from bottom: for *longer* read *shorter*.
10. P. 328; line 6 from top: for *four* read *seven*.
11. P. 332; line 4 from top: for $1\frac{3}{4}^{\circ}$ read *about* 4° .
12. P. 337; line 10 from bottom: for *11h* read $5\frac{1}{2}$ hours.
13. P. 337; line 3 from bottom: for *at every revolution* read *at two full moons out of three*.
14. P. 337; line 2 from bottom: for *every new moon* read *with corresponding frequency*.
15. P. 394; line 3 from bottom: for *ten* read *five*.
16. P. 395; line 20 from top: for *discovery* read *perihelion passage*.
17. P. 395; line 22 from top: for *pass the perihelion* read *were discovered*.
18. P. 407; line 5 from top: for $\frac{1}{250000}$ read $\frac{1}{1000000}$.
19. P. 407; line 6 from top: for *twenty-four* read *six*.
20. P. 415; line 3 from top: for *fixed* read *convex*.
21. P. 439; line 18 from top: for *Thomson* read *Thomsen*.
22. P. 475; line 14 from bottom; for $\frac{1}{27000}$ read $\frac{1}{37000}$.
23. P. 482; line 6 from bottom: for *twelfth* read *ninth*.
24. P. 498; table: mass of α Geminorum should be 0.054.
25. P. 499; article 879. The relation deduced by Monck is true only on the assumption that the stars compared are of *equal density*: a most serious restriction.
26. P. 503; line 8 from bottom: for *10,000 or 11,000* read *8,000*.
27. P. 508; line 5 from bottom: for *1,000 and 2,000* read *2,000 and 3,000*.

28. P. 510; line 6 from top: for 37° read 27° .

29. P. 530; table of Saturn's satellites: the period of Titan is 15d, etc., instead of 13d, etc., as given.

There are a few other typographical errors, but, so far as I now know, none of any real importance.

TO BE CONTINUED.

MEETING OF THE PERMANENT COMMITTEE OF THE ASTRO-PHOTOGRAPHIC CONGRESS.

The following notes are not quite complete, but will doubtless be of interest.

Several members of the Committee assembled on Sept. 12 at the Paris Observatory, and after some preliminary business drew up the following programme for discussion:—

A. Execution of the Photographic Work.

1. Accuracy with which the center of the plate is to be pointed on the selected point of the heavens.
2. Exposing shutters.
3. Construction and mounting of plate-holders.
4. Dimensions of plates and réseaux, and maximum admissible deformation of stellar images.
5. Amount of overlapping of plates.
6. Construction of réseaux.
7. Distribution of work among Coöperating Observatories.
8. Plates; plate-glass or ordinary; chemical formula; manufacturer; testing.
9. Shall the sensitiveness of plates for Chart and for Catalogue be the same?
10. Method of impressing réseau on plates: shall a réseau be used for the Chart plates as well as for the Catalogue?
11. Times of exposure for the two series.
12. Development.
13. Fixing, varnishing, etc.
14. Test objects for the different Observatories.

B. Use of Plates when taken.

15. Nature of method of measurement (distance and position angle; rectangular axes. parallactic method).
16. Measures to be taken to lighten the labor of the measurements in closely-starred portions of the sky.
17. Shall there be a central bureau to measure the plates?

18. Shall there be a special committee to consider the reproduction of the plates and the publication of the Map of the Heavens?

These points were decided at the actual meeting of the committee somewhat as follows:

1. It was decided that the actual center of the plate should not be more than about 5" distant from the point selected in the sky.

2. It was decided to use an exposing shutter, but the actual form was left to discretion.

3. MM. Christie, Gautier, and Paul Henry appointed as committee to consider this question.

4. Size of field unanimously adopted as 2° square. MM. Bakhuyzen and Henry reported that within this area on the Paris plates measurement showed the errors to be very small. The réseau to be 130 mm. square as proposed by Vogel, lines 5 mm. apart; and Christie's proposal that plates be 160 mm. square was adopted unanimously.

5. Overlapping of 5', as suggested by Vogel, proposed by Kapteyn.

5. Vogel's offer to construct and verify the réseaux was accepted. The lines to be continuous and not mere crosses at the points of intersection.

7. Committee of Beuf, Christie, Kruls, and Loewy proposed the following distribution, which was adopted:

Observatory.	Decl.	°	Observatory.	Decl.	°
Helsingfors.....	+ 90 to + 70		S. Fernando.....	0 to - 6	
Potsdam.....	+ 70 + 58		Mexico.....	- 6 - 12	
Oxford.....	+ 58 + 48		Tacubaya.....	- 12 - 18	
Greenwich.....	+ 48 + 40		Rio.....	- 18 - 26	
Paris.....	+ 40 + 32		Santiago.....	- 26 - 34	
Vienna.....	+ 32 + 24		Sidney.....	- 34 - 42	
Bordeaux.....	+ 24 + 18		Cape.....	- 42 - 52	
Toulouse.....	+ 18 + 12		La Plata.....	- 52 - 70	
Catania.....	+ 12 + 6		Melbourne.....	- 70 - 90	
Algiers.....	+ 6 0				

8. Plate-glass decided unanimously. Chemical formula left open.

9. Sensitiveness to be the same for both.

10. Vogel's method for impression of réseau adopted. Réseau to be used for both series.

11. The Paris Observatory will prepare a series of standard plates, giving stars to 14.0 and 11.0 magnitudes re-

spectively, for distribution to each of the Coöperating Observatories; the time of exposure to be adjusted so as to compare properly with these standards. For definition of magnitude 11.0 as limit for the Catalogue series, it was decided that as 7.0 and 9.0 are well-understood magnitudes, the photographic difference between them should be determined and carried on from magnitude 9.0 to get magnitude 11.0.

For the Catalogue plates there are to be two exposures on each plate; the first to give stars to magnitude 11.0, the second of one quarter the duration with a displacement of about 0.2 mm., as a check on the first.

12, 13. The plates to be tanned. Otherwise left open.

14. See 11.

15. Referred to a committee.

16, 17, 18. The question of a Catalogue was left open, and one or more bureaus to be established for such observatories as cannot measure their own plates. Photographic copies of all plates to be taken and preserved in selected places in case of accident to the negative.—*Observatory.*

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury may be seen in the morning a half hour before sunrise until about Nov. 20, after which time it will be too close to the sun. It will come to superior conjunction with the sun Dec. 7, and will be at aphelion or greatest distance from the sun on the same day.

Venus is morning star, but is moving rapidly eastward and getting nearer the sun, so that it is not in so favorable a position for observation as in the past months. This planet will be visible in the morning, however, until the end of the year. Venus will be in conjunction with Uranus Nov. 9, 1 P. M., $1^{\circ} 08'$ north, and with the moon Nov. 21, 4 A. M., 3° south.

Mars will be at its greatest distance from the sun Nov. 11, and in conjunction with the moon, $4^{\circ} 08'$ south, Nov. 18, 5 P. M. Its course is through Virgo, passing $2'$ north of the

star γ Nov. 16 at 2 A. M., $1^{\circ} 20'$ south of γ Nov. 26, and $20'$ south of θ Dec. 8. The October number of *L'Astronomie* contains an interesting article by Philippe G  rigny on "The Tides on Mars." The writer has attempted to investigate the tides which would be produced upon Mars by the two satellites, with a view of explaining some of the changes which have been observed upon the face of the planet, and which have been suggestive of periodical inundations. The greatest difficulty in the way of such an investigation is our ignorance of the mass and density of the satellites. Assuming the diameters to be 12 km. for the inner and 10 km. for the outer, and the densities equal to that of the planet, the writer finds the tides to be insignificant. The bulging of an ocean of water due to the attraction of the first satellite would be only 1.79 mm. or less than one-tenth of an inch, and that produced by the second satellite still less. If, however, the diameters of the satellites be greater (which is probably true) than the above estimates, the resulting tides will be greater in proportion to the cubes of the diameters, and it may be possible to explain some of the changes observed on the planet as the result of high tides overflowing the lowlands and filling up the long narrow valleys or channels.

Jupiter will continue to be visible as evening star setting in the southwest about two hours after sunset. Its altitude is too low for good observations. We therefore cease to give the tables of the satellites and the red spot. Jupiter will be in conjunction with the moon Nov. 25 but will not suffer occultation in northern latitudes.

Saturn is in Leo a little east of Regulus, and may be observed after midnight. He will be in quadrature with the sun Nov. 25, in conjunction with the moon Dec. 13, 4 P. M., and stationary in the sky Dec. 15, 1 A. M. The inclination of the plane of the rings to the line of sight is now only eight degrees. This month we begin again to give the times of elongation of the five brighter satellites of Saturn. We omit the others as not likely to be seen by any observers who do not already possess a complete ephemeris.

Uranus is a morning star, and may be found about 2° northeast of Spica in Virgo. On the morning of Nov. 20 it will be about 4° south of the moon.

Neptune is in Taurus about one-third of the way from Aldebaran to the Pleiades, and may be observed during the whole of the night. He will be in opposition to the sun Nov. 24. Dec. 6 at 2h 34m A. M. *Neptune* will be directly north of the Moon at a distance of about the moon's diameter.

Sun-spots were observed at Carleton College Observatory Sept. 24, 26, 27, 28, Oct. 9, 10, and 17. No spots were visible Sept. 18, 19, 20, 21, Oct. 3, 4, 7, 11, and 14.

MERCURY.

	R. A. h m	Decl. ° ' "	Rises. h m	Transits. h m	Sets. h m
Nov. 25.....	15 38.3	-19 15	6 35 A.M.	11 19.0 A.M.	4 03 P.M.
Dec. 5.....	16 44.1	-28 11	7 21 "	11 45.2 "	4 10 "
15.....	17 52.8	-25 11	8 00 "	12 14.4 "	4 29 "

VENUS.

Nov. 25.....	14 45.3	-14 33	5 22 A.M.	10 26.1 A.M.	3 31 P.M.
Dec. 5.....	15 35.4	-18 12	5 48 "	10 36.6 "	3 25 "
15.....	16 27.4	-21 01	6 13 "	10 49.2 "	3 26 "

MARS.

Nov. 25.....	12 34.5	- 2 11	2 21 A.M.	8 15.8 A.M.	2 11 P.M.
Dec. 5.....	12 56.4	- 4 29	2 13 "	7 58.3 "	1 44 "
15.....	13 18.1	- 6 43	2 04 "	7 40.7 "	1 18 "

JUPITER.

Nov. 25.....	18 42.4	-23 14	9 58 A.M.	2 22.5 P.M.	6 47 P.M.
Dec. 5.....	18 51.7	-23 04	9 27 "	1 52.5 "	6 18 "
15.....	19 01.3	-22 52	9 57 "	1 22.7 "	5 49 "

SATURN.

Nov. 25.....	10 24.2	+11 31	11 12 P.M.	6 01.9 A.M.	12 51 P.M.
Dec. 5.....	10 25.2	+11 28	10 34 "	5 23.5 "	12 13 "
15.....	10 25.9	+11 29	9 55 "	4 44.5 "	11 34 "

URANUS.

Nov. 25.....	13 32.8	- 9 05	3 46 A.M.	9 13.6 A.M.	2 41 P.M.
Dec. 5.....	13 34.7	- 9 15	3 10 "	8 36.5 "	2 03 "
15.....	13 36.3	- 9 25	2 33 "	7 58.7 "	1 25 "

NEPTUNE.

Nov. 25.....	4 05.7	+19 08	4 21 P.M.	11 44.3 P.M.	7 08 A.M.
Dec. 5.....	4 04.6	+19 05	3 40 "	11 03.8 "	6 27 "
15.....	4 03.5	+19 02	3 00 "	10 23.4 "	5 46 "

THE SUN.

Nov. 25.....	16 06.8	-20 54	7 11 A.M.	11 47.7 A.M.	4 25 P.M.
Dec. 5.....	16 50.0	-22 28	7 22 "	11 51.1 "	4 20 "
15.....	17 34.0	-23 19	7 30 "	11 55.6 "	4 20 "

Occultations Visible at Washington.

Date.	Star's Name.	Magni- tude.	IMMERSION.			EMERSION.			Dura- tion. h m
			Wash. Mean T.	Angle f'm N. P't.	Wash. Mean T.	Angle f'm N. P't.	Wash. Mean T.	Angle f'm N. P't.	
Nov. 24...	4 Sagittarii.....	5½	5 24	92	6 25	266			1 01
27...27	Capricorni.....	6½	4 23	44	5 36	276			1 13
30...30	Piscium.....	4½	10 47	100	11 38	202			0 50
Dec. 14...	Virginis.....	4	18 53	137	20 12	291			1 20

Phases of the Moon.

		Central Time.	
		d	h m
Last Quarter.....	Nov. 15	2	36 P. M.
New Moon.....	" 22	7	44 "
First Quarter.....	" 29	11	29 A. M.
Full Moon.....	Dec. 7	3	52 "
Last Quarter.....	" 15	8	58 "

Elongations and Conjunctions of Saturn's Satellites.

[Central time; E = east elongation; W = west elongation; I = inferior conjunction (north of planet); S = superior conjunction (south of planet.)]

JAPETUS.

Nov. 5 S. Nov. 25 E. Dec. 15 I.

TITAN.

Nov. 16 Midnight. I. Nov. 28 Midnight. E. Dec. 10 11 P. M. S.
 20 " W. Dec. 2 " I. Dec. 14 10 " E.
 24 " S. 6 11 P. M. W.

RHEA.

Nov. 15 7.1 A. M. E. Nov. 28 8.5 P. M. E. Dec. 12 9.7 A. M. E.
 19 7.6 P. M. E. Dec. 3 9.0 A. M. E.
 24 8.0 " E. 7 9.4 P. M. E.

DIONE.

Nov. 16 3.4 A. M. E. Nov. 27 2.2 A. M. E. Dec. 8 1.0 A. M. E.
 18 9.1 P. M. E. 29 7.9 P. M. E. 10 6.7 P. M. E.
 21 2.8 P. M. E. Dec. 2 1.6 P. M. E. 13 12.3 P. M. E.
 24 8.5 A. M. E. 5 7.3 A. M. E.

TETHYS.

Nov. 16 9.6 A. M. E. Nov. 27 5.5 P. M. E. Dec. 7 4.0 A. M. E.
 18 6.9 A. M. E. 29 2.8 P. M. E. 9 1.3 A. M. E.
 20 4.3 A. M. E. Dec. 1 12.1 P. M. E. 10 10.6 P. M. E.
 22 1.6 A. M. E. 3 9.4 A. M. E. 12 7.9 P. M. E.
 23 10.9 P. M. E. 5 6.7 A. M. E. 14 5.2 P. M. E.
 25 8.2 P. M. E.

Comet d 1889 (Brooks, July 6) is in the west end of constellation Pisces and moving slowly northeast. The similarity of the preliminary elements of this comet, especially the inclination, to those of comet 1884 II (Barnard) computed by H. V. Egbert, led Dr. K. Zelbr to test their identity. He finds that the observations of Brook's comet cannot be represented by the elements of comet 1884 II (*A. N.* 2926). He has computed a new set of elliptic elements, from observations made July 8, Aug. 5 and 19 which represent within small errors a later observation made Aug. 30:

$T = 1889 \text{ Sept. } 19.2964$ Berlin mean time.

$\omega = 337^\circ 52' 11.4''$
 $\Omega = 18 \ 52 \ 47.7$
 $i = 6 \ 01 \ 07.5$
 $\varphi = 29 \ 41 \ 50.6$

} Mean equinox 1889.0

$\log \mu'' = 2.657852$

$\log a = 0.472470$

$a = 2.96804.$

Period = 7.8 years

The following ephemeris is by Dr. O. Knopf (A. N. 2926):

1889			App. α	App. δ	$\log r$	$\log J$	Br.
Berlin Mean Time.	h	m	s	°			
Nov. 5.5	23	42	56	-2 03.6	0.2988	0.0745	1.7
7.5		43	44	1 48.6			
9.5		44	39	1 33.1	0.3001	0.0888	1.6
11.5		45	40	1 17.1			
13.5		46	49	1 00.8	0.3015	0.1025	1.5
15.5		48	04	0 44.1			
17.5		49	25	0 27.0	0.3030	0.1163	1.4
19.5		50	52	-0 09.5			
21.5		52	25	+0 08.4	0.3046	0.1303	1.3
23.5		54	04	0 26.7			
25.5		55	49	0 45.2	0.3063	0.1445	1.2
27.5		57	39	1 04.1			
29.5	23	59	34	1 23.3	0.3082	0.1587	1.1
Dec. 1.5	0	01	34	1 42.8			
3.5		03	39	2 02.6	0.3101	0.1728	1.0
5.5		05	48	2 22.6			
7.5	0	08	02	+2 42.9	0.3121	0.1868	0.9

Comet *b* 1889 (Barnard, March 31) is in the middle of the constellation Cetus, moving southwest. We have at hand no ephemeris extending beyond Nov. 5.

The Solar Corona. The volume containing the reports on the observations of the total eclipse of the sun, Jan. 1, 1889, published by the Lick observatory, has been received.

The introduction to this report, covering twenty-two pages, is written by Professor Holden. It is a detailed statement of great interest, setting out in a clear way, the advancement made by observation and study of the last total solar eclipse. His conclusions are given in full, and are as follows:

I. That the characteristic coronal forms seem to vary periodically as the sun-spots (and Auroras) vary in frequency, and that coronas of 1867, 1878, and 1889 are of the same strongly marked type, which corresponds, therefore, to an epoch of minimum of solar activity.

II. That so-called polar rays exist at all latitudes on the sun's surface, and are better seen at the poles, simply because they are there projected against the dark background of the sky, and not against the equatorial extensions of the outer corona. There appears to be also a second kind of rays or beams that are connected with the wing-like extensions.

These latter are parts of the "groups of synclinal structure" of Mr. Ranyard.

III. The outer corona of 1889 terminated in branching forms. These branching forms of the outer corona *suggest* the presence of streams of meteorites near the Sun, which by their reflected light, and by their native brilliancy, due to the collisions of their individual members, *may* account for the phenomena of the outer corona.

IV. The disposition of the extensions of the outer corona along and very near the plane of the ecliptic might seem to show that if the streams of meteorites above referred to really exist, they have long been integral parts of the solar system.

Note.—The conclusions III. and IV. appear to be contradictory to that expressed in I. The electrical theory announced by Dr. Huggins in the Bakerian lecture for 1885. seems to reconcile the conclusions I., III., IV.

V. The photographs of the corona which were taken just before Contact II. and just after Contact III., prove the corona to be a solar appendage, and are fatal to the theory that any large part of the coronal forms are produced by diffraction. (See the photographs of Mr. Woods and a discussion of them in the reports of Mr. Keeler.)

VI. The spectroscopic observations of Mr. Keeler show conclusively that the length of a coronal line is not always an indication of the depth of the gaseous coronal atmosphere of the sun at that point, and hence to indicate the important conclusion that the true atmosphere of the sun may be comparatively shallow.

VII. Mr. Keeler also draws the further conclusion in his report that the "polar" rays are due to beams of light from brighter areas of the sun illuminating the suspended particles of the sun's gaseous envelopes.

In order that this conclusion may stand, it is necessary to show that all these "polar" beams are composed of rectilinear rays.

It appears to me that the beams Nos. 62 and 64 of the Index-Diagram (among others) present serious difficulties of interpretation in this regard.

VIII. The conclusions respecting the photographic and photometric values of the corona and surrounding sky at time of totality are exhibited in the tables accompanying the reports of myself, Mr. Barnard, Mr. Leuschner, and Dr. Passavant. An important conclusion from these meas-

ures seems to be that it is impracticable to photograph the corona in full sunshine with our present plates, and that a photographic search for *Vulcan* is hopeless.

Queries. Query No. 23, which asked for the cause of the so-called polar filaments, has not yet been satisfactorily answered. It was hoped that more light would be gained by the observations and the photographs of the last total solar eclipse. The photographs by Professor Pickering and Mr. Barnard of Lick Observatory show this phenomenon well,—it is believed better than in any other way previously. In Professor Holden's study of the Lick photographs much that is interesting appears as to the location of these filaments on the solar surface: that they were found not only in the regions of the poles, but, as he thinks, scattered all over the surface of the sun, and that, if the bright background of the equatorial regions were removed, the general appearance would be quite the same for the class having the ordinary polar form. The "groups of synclinal structure" are still more puzzling, and seem to neutralize all that the polar form might suggest in the direction of magnetic force as a cause. The last eclipse gave considerable of detail which may bring out useful results in the light of the coming December eclipse observations which will be made in Africa and South America.

24. The shadow bands; as some observers call them, which are seen about the time of the third contact, in the total solar eclipse, are probably the diffraction effects of solar rays passing over the advancing limb of the moon near the beginning and end of totality. This is the reason why other observers call the phenomena diffraction bands. Exactly how the bands are formed does not yet clearly appear. As an illustration of how they sometimes appear we give a part of the report of one of the observers of the eclipse of July 27, 1878. He said: "Before totality I had observed the diffraction bands flying across the roof of the building, but failed to catch the moment of their beginning. They commenced immediately on the occurrence of the III contact and lasted 48 seconds moving from west to east. This observation was carefully made. They coursed after each

other very rapidly, seeming about three feet from center to center, the dark band being, say six inches wide, the interior being bright. In reality the dark and bright spaces must have been of equal width, but the appearances were as stated." These observations were confirmed by others at the same place. An attempt to count the number of these bands that passed a given point in a second of time failed, as might have been expected.

Professor Winslow Upton observed the same phenomena at the last total solar eclipse, Jan. 1, 1889.

Mr. Charles E. Myers has furnished two neat solutions of the example in elementary algebra given in our last issue. The example was to find x and y in the following:

$$\begin{aligned}x^2 + y &= 7 \\x + y^2 &= 11\end{aligned}$$

One method is as follows:

Adding (1) and (2), $x^2 + x + y^2 + y = 18$

Adding $\frac{1}{4}$ to both numbers, $x^2 + x + \frac{1}{4} + y^2 + y + \frac{1}{4} = 18\frac{1}{2}$
 $= \frac{74}{4} = \frac{25}{4} + \frac{49}{4} \therefore x^2 + x + \frac{1}{4} = \frac{25}{4}$ and $y^2 + y + \frac{1}{4} = \frac{49}{4}$
 whence $x = 2$; $y = 3$.

EDITORIAL NOTES.

On and after December 1, the annual subscription price of the MESSENGER will be \$3 to American subscribers, and those of the Canadian provinces; to foreign subscribers, in countries included in the Postal Union \$3.25, and to those of other countries \$3 plus the cost of annual postage.

The chief reason for increasing the subscription price is to cover a portion of the expense to be incurred in contemplated improvements which will begin with the first number of 1890. We will briefly indicate two or three points of change which have been under consideration for some time.

One is, as already suggested, the addition regularly of a series of notes on the bibliography of astronomy, which we expect will be full enough to cover all important topics from all sources within reach. This very valuable matter will be furnished by Professor W. C. Winlock, Superintendent of the

Bureau of Exchanges at the Smithsonian Institution, Washington, D. C. THE MESSENGER is fortunate in securing the services of one, so ready in this kind of work and surrounded as he is, with rare facilities for gathering the information desired.

Another feature is, the purpose to make the current astronomical notes and news items fuller and more general. This probably will involve a new and better plan for this part of our work than we have previously used. A third point, and the last that we can now mention, pertains to articles of general scientific interest that should be accompanied by expensive engravings. An illustration of this feature may be found in the frontispiece of our last issue. It is earnestly hoped that our large list of subscribers will not feel this change of price a burden to them, but rather that they will continue their hearty support as in the past, and also aid us in securing many new subscribers.

Change of Latitude. At an international meeting of scientists in the interest of geodetic survey work, held at Rome in 1884, a proposition was made by Professor Fergola and adopted, that simultaneous determinations of latitude should be made at two places nearly in the same parallel of latitude, but at very considerable distances apart in longitude, in order, if possible, thereby to measure any changes in the earth's axis, in the body of our planet as detected in the variation of latitude at certain points of the earth's surface.

In order to carry on this delicate and very important piece of work, Dr. F. Porro, Director of the Astronomical Observatory of the Royal University of Turin, Italy, has recently, by letter very politely suggested that the Observatory of Carleton College and his own are well located for doing this work, and requests that we favorably consider the proposition. To this we have replied that our Observatory will very gladly join him in this, and assign one of our transit instruments to it, and that we will begin as soon as he is ready and his detailed plan of work is known.

Observations for best work of this kind are taken in the Prime Vertical, and our Observatory has excellent facilities for such observations, with a good transit instrument already mounted in the Prime Vertical.

The Orbit of Sirius by J. E. Gore is a short paper of interest. From it is learned the fact that the components of this wonderful binary are now approaching their minimum distance, which is becoming rapidly very difficult to measure even by the aid of the largest telescopes. The companion was discovered by Alvan Clark in 1862, and Mr. Gore has collected all the known measures since that time, and from them deduced the following elements:

$P = 58.5$ years	$\Omega = 49^{\circ}59' (1880.0)$
$\tau = 1896.47$	$\lambda = 216^{\circ}18'$
$\varepsilon = 0.4055$	$a = 8''.58$
$i = 55^{\circ}23'$	$\mu = -6^{\circ}.156.$

The method used was to plat all the observations (corrected for precession to 1880.0) and draw the interpolating curve, and the apparent ellipse in the usual way, and then compute by Professor Glasenapp's method the co-efficients of the general equation. These values were substituted in Kowalsky's equations, from which the geometrical elements of the orbit were found.

With Gylden's parallax for Sirius the above values of P and a give

Sum of masses = 26.298 (sun's mass 1).

Mean distance 44.45 (earth's mean distance from sun = 1). According to the ephemeris the minimum distance of the components will occur in 1893 with a value of $3''.23$, and a position angle of $310^{\circ}.88$.

Professor Charles S. Howe, formerly in the chair of Mathematics and Astronomy at Buchtel college, has been recently chosen to fill the Kerr Professorship of Mathematics in the Case School of Applied Science at Cleveland, Ohio. From all that we know of it Professor Howe will find his new position a most congenial one, with favoring prospects in the line of his chosen work.

Smith Observatory. Professor Chas. A. Bacon, Director of Smith Observatory, Beloit College, Wis., has a new Brashear helioscope which he is using with great satisfaction in daily study of the sun. He is also doing some work in celestial photography. We are to be favored with reports for publication soon.

Notices from Lick Observatory. By favor of Professor Holden we have the following notices prepared by members of the staff, at the Lick Observatory, from the publications of the Astronomical Society of the Pacific:

Photographing the Milky Way. The great success obtained by Mr. Barnard in his preliminary experiments with the Willard portrait lens ($a = 5.9$, $f = 30.7$) has led to the determination to employ it in making a systematic study of the Milky Way by photography. For this purpose it has been mounted at the object-glass end of the tube of the great telescope, and arrangements made by which the lens can be capped and uncapped from the eye end. The driving clock of the great telescope (with a control) will keep the camera directed at the star-group chosen during an exposure of two hours. An independent equatorial stand for this instrument is very desirable, but cannot be had at present. Plates 8×10 are used, which correspond to about $16^\circ \times 20^\circ$. The definition is good over the central 10° or 11° . E. S. H.

Occultation of Jupiter, 1889, September 3.

Initials of the Observer.....	J. E. K.	E. E. B.	C. B. H.	A. O. L.
Phenomenon Observed.	Lick Observatory Mean Time.			
	h m s	m s	m s	m s
First contact of Jupiter.....	5 25 39.1*	25 41.3	25 43.5†	25 41.6
Second contact of Jupiter.....	5 27 50.7	27 47.3	27 47.8	27 43.9
Reappearance of Satellite II..	6 11 33+	.....	.....	.....
Reappearance of Satellite IV.	6 16 46.2	.....	.....	.....
Third contact of Jupiter.....	6 19 17.2	.....	.....	19 26.2
Fourth contact of Jupiter.....	6 21 39+	21 38.3::	21 39.5::	21 32.2
Reappearance of Satellite I....	6 23 12.8	23 15.7::	23 16.0‡	.....
Instrument employed.....	36-in. tel.	12-in. tel.	6½-in. tel.	Comet seeker.

OBSERVERS' NOTES.—* 2 secs. late; † 3-5 secs. late; ‡ 2-3 seconds late.

Observers: Mr. Keeler = J. E. K.; Mr. Barnard = E. E. B.; Mr. Hill = C. B. H.; Mr. Leuschner = A. O. L.

Mr. Schaeberle obtained several photographs of the moon and Jupiter after fourth contact.

Examination of Stellar Photographs. If it is desired to obtain *all* the information which can be had from a given negative, it is necessary to make a positive copy of it on glass, and to examine both negative and positive independently. Each presents a different set of contrasts. The negative will show the empty spaces and lanes between stars; the positive will show the arrangement of the stars

themselves. It is only by examining both that *all* the information can be had from a given exposure. This is certainly true for stellar photographs, and it is even more important in regard to photographs of surfaces,—as nebulae, the corona, etc. It should also be remembered that no single negative can establish the existence of a new nebula. At least two are required.

Experiments by Mr. Barnard have shown that many features may be brought out by the simple device of copying the whole of an 8×10 plate on a plate of $3\frac{1}{4} \times 4\frac{1}{4}$ inches. This process is analogous to the automatic one by which a person places a picture to be viewed at an appropriate distance for seeing the particular details he wishes to examine. Enlargements of negatives are also sometimes serviceable. These simple precautions are worth mentioning, as they help to emphasize a fundamental point, namely,—that it is far more important to extract all possible information from a few photographs, than to make large collections of negatives without sufficiently examining each of them. E. S. H.

Review of the Early Numbers of the Publications of the Astronomical Society of the Pacific. The *Vierteljahrsschrift* of the German Astronomical Society (Vol. 24, 1889, p. 210) has a very friendly review of Nos. 1 and 2 of our own *Publications*, written by Professor E. Schoenfeld, Director of the Observatory at Bonn. The last paragraph is:

“The reviewer has no right to speak in this place in the name of the *Astronomische Gesellschaft*; but, in his own name and in that of other members, he expresses a hearty greeting to the new Society which has been founded on the Coast of the Pacific Ocean and wishes for it all success and prosperity.”

It will be gratifying to our members to know of this early and courteous recognition of our modest beginnings. E. S. H.

Note on the Corona of January 1, 1889. Professor Tacchini has a note in the *Atti della R. Accademia dei Lincei* 1889, page 472, on the corona as shown in a positive-copy on glass of one of Mr. Barnard's negatives. The corona extends, he says, from $+64^\circ$ to -68° on the west limb of the sun, and from $+53^\circ$ to -68° on the east limb. These are

about the limits of the zone of the maximum frequency of protuberances defined by Professor Tacchini's own observations. Two of the protuberances of the photograph were observed at Rome and at Palermo. The other protuberances shown on the photograph were not seen by the spectroscope, and Professor Tacchini surmises that they belong to the class of *white* protuberances discovered by him at the eclipses of 1883 and 1886. This surmise is completely corroborated by the observations of Professor Swift (L. O. Eclipse Report, 1889, page 203).

E. S. H.

The Gundlach Optical Co. of Rochester, N. Y., is making a low-power eye-piece with a large field—something like half a degree—for the use of visitors who come to see the moon. Such an eye-piece will show enough of the lunar surface to make a *picture* with a background of sky, which is what is really needed to convey the effect. The eye-pieces used in the regular astronomical observations have fields of view of hardly more than 10' of arc, and, hence, only serve to show a limited portion of the Moon's surface—less than one tenth usually. As the image of the moon in the large telescope is 6.51 inches in diameter, it follows that the field lens of the new eye-piece must be of about the same dimensions. It will be useful in real work; also, for objects like nebulae and comets where a large field and full contrast are required.

E. S. H.

Notes on Double-Stars. The Herschel companion to ψ^1 Aquarii is shown in the 36-inch telescope to be a very close double-star. From a single measure the distance appears to be less than 0".15, and, of course, it is a different object, even in a large refractor. This companion has the same proper motion as the large star, and the relative change is practically nothing since the measures of Struve, in 1836, when the distance was 49".63 in the position-angle of 312°.2.

Professor Hough found the neighboring star ψ^3 (95) Aquarii double, with the Chicago 18½-inch refractor, in 1884, the companion being eleventh magnitude, at a distance of a little more than 1". Last year this was noted independently here with the 12-inch, and measured on three nights, the result being substantially the same as the single meas-

ure by Hough in 1884. In the course of the observations given above, this star was looked at with the 36-inch on two or three nights, but there was not the faintest trace of the companion. I am wholly unable to account for this failure, as there was apparently no change in the preceding four years. It should be carefully watched hereafter.

The sixth magnitude star, 44 Cassiopeiæ, has a minute attendant, hitherto unseen, at a distance of $1''.7$ from the principal star.

Several new pairs have been found in the Pleiades, one of them following Alcyone 64s and about $4'$ north. This is a difficult pair, as the distance is only $0''.3$, and the components below the ninth magnitude. Another new pair, still more difficult, is 55s following Pleione (28 Tauri). The distance of this pair is about $0''.4$, but the components are only $11\frac{1}{2}$ magnitude.

Since the time of Herschel, 67 Ophiuchi has been known as a wide double-star ($54''$). The large telescope shows a very faint star at a distance of $6''.8$.

The star D. M. 63°, 1618 has a very small companion at a distance of $4''.3$. The principal star is brighter than sixth magnitude, but is strangely wanting in nearly all of the star catalogues covering this part of the heavens. It is not in the B. A. C., Radcliffe (1 and 2), Lalande, Argelander U. N., Heis, Piazz, Bradley, Romberg, AOe, Grant, D'Agelet, Armagh, Yarnall, Bonn observations. In fact, it is found only in the D. M. and Rumker (No. 8289), the magnitudes being 5.9 and 5.6, respectively. In the Harvard Photometry the magnitude is 5.82. In observing it here as a double-star the magnitude was estimated 5.8. It does not appear to be variable, and is probably a rare example of star catalogue omissions. The attention of meridian observers is called to this object.*

The double star, γ 2816, consists of a sixth magnitude primary, and two $7\frac{1}{2}$ m. companions with distances from the larger star of about $12''$ and $20''$, respectively. These stars have remained relatively fixed since 1832. The large telescope shows a minute companion within $1''.5$ of the large star.

* This star will be observed by Professor Schaeberle with the L. O. meridian circle. E. S. H.

The fifth magnitude star, 2 Andromedæ, is a very close and difficult pair, the distance being only $0''.8$, and the components quite unequal. This was suspected with the 12-inch, and verified and measured with the 36-inch.

Herschel noted a ninth magnitude companion to α Casiopeæ at a distance of $63''$. The large telescope shows a very faint star at a distance of $17''.5$.

The distance of the close pair in γ Andromedæ ($\theta^{\circ} 38$) is now less than $0''.1$. It is very difficult, and the best conditions are necessary to see the elongation at all with the large telescope.

The binary star, 7 Tauri, has been rapidly changing. The distance now is $0''.30$.

The large refractor fails to show any third star in the system of 70 Ophiuchi, and both components are single with all powers. At one time 72 Ophiuchi was thought to be double ($\theta^{\circ} 342$), but no companion can be seen here. s. w. b.

Observations on the Near Approach of Mars and Saturn on September 19, 1889. The eastern sky was thick with haze when the two planets rose, and they were not visible until a considerable altitude was attained. At about 4 A. M. they could be seen dimly with the naked eye; Mars, small and insignificant, slightly east of Saturn. As soon as the images were at all measurable, I made a series of micrometrical observations of the two for position angle and distance, and for differences of right ascension and declination, using the 12-inch equatorial.

Following are the measures which are corrected for refraction in distance and in the $J\delta$ and $J\alpha$; the times being Mt. Hamilton mean time:

	d	h	m	s	
1889. Sept.	19	16	16	39.	Position angle of Mars, $101^{\circ}.0$ (3).
"	"	19	16	24 24.	Dist. bet. outer limbs of Mars and Saturn, $356''.1$ (3).
"	"	19	16	29 14.	" " nearer " " " $342''.3$ (3).
"	"	19	16	34 19.	" " center and center, $358''.8$ (3).
"	"	19	16	39 49.	Position angle of Mars, $101^{\circ}.8$ (4).
"	"	19	17	36 29.*	$J\delta$ Mars-Saturn $-1' 39''.2$ (5) apparent.
"	"	19	17	45 49.*	$J\alpha$ Mars-Saturn $-0m 29.91s$ (11) apparent.

* These times are for the bisection of Mars.

The most striking feature was when the two planets were fading from the advent of daylight. At the approach of day Saturn assumed a pale, ashy hue, with a slight tinge of yellow, while Mars retained its luster in a surprising manner,

being of a strong orange yellow in color; its north polar cap stood out strikingly towards the close of the observations, a dark marking being also visible near the middle of the disc. Saturn ceased to be visible in the telescope at 18h 6m, the last glimpse being had a few seconds earlier. At this time Mars was easily conspicuous, the sun being 5° or 6° high and the sky pretty thick. At 18h 10m Mars began to grow pale. At 18h 25m it was still visible but very pale and easily lost in the field, though it could have been followed for some time longer. By the time the planets were high enough to observe with the large telescope they had separated too far to be brought into the field of view of the largest eyepiece.

E. E. B.

Mt. Hamilton, Sept. 20, 1889.

The Todd Eclipse Expedition. By the Philadelphia Press it is recently learned, that the United States expedition to Africa, to observe the total solar eclipse of Dec. 21 and 22 set sail from New York on the Pensacola the early part of last month. The party, including the astronomers, numbered about twenty-five in all. Those from Washington were E. J. Loomis, F. H. Bigelow, W. Harvey Brown, Cleveland Abbe, and G. D. Preston. A number of Professors from Eastern colleges also accompany the expedition.

A Telescope for Hanover College. Messrs. Warner and Swasey, Cleveland, O., have received an order for a 7½-inch equatorial telescope, with all the accessories to make the instrument complete, for Hanover college, Hanover, Indiana. The same firm are to furnish a dome and the architectural plans for a new Observatory.

Mr. Ambrose Swasey, of Warner and Swasey, has returned from four months of travel in Europe. While absent he visited many of the principal observatories and spent some time in the study of newer forms and improvements for astronomical instruments.

Spectrum of R. Andromedæ. T. E. Espin reports bright lines seen in the spectrum of R. Andromedæ on Sept. 25. The F. line was very bright. This was circular number 25 from Wolsingham Observatory.

Miss E. M. Bardwell, in charge of the Observatory at Mount Holyoke Seminary and college, South Hadley, Mass., took measures of the distance between Mars and Saturn at 4h 9m local sidereal time, and found the two planets 1' 38" apart. At 5h 19m, they, were distant 2' 46". Clouds interfered after this time.

Marshall D. Ewell, address 97 Clark street, Chicago, Ill., gives notice that he has revoked the agency for the sale of his micrometric rulings hitherto conferred upon *The Microscope*, because of the sale of that journal. Future orders and correspondence should be addressed to him as specified above.

Himmel and Erde for October is one of the finest members of this new magazine yet issued. It has a beautiful frontispiece, photogravure plate of the disc of the sun showing sun-spots, faculæ and general granulation of the solar surface. If this picture be a faithful copy of any photograph it is certainly one of high excellence.

Spectrum of Saturn and Uranus.—We notice in the last *Nachrichten* (No. 2927), just as we go to press, an interesting article on the spectrum of Saturn and Uranus, by James E. Keeler, of Lick Observatory. The last part of the article is accompanied by a fine lithographic plate of the spectrum of Uranus. Fuller notice of this will be given later.

Asaph Hall, Jr., has been appointed Assistant Astronomer in the Naval Observatory, Washington, D. C., in the position formerly held by W. C. Winlock.

Errata in First Article. Page 385, line 13 from top for *physicists* read *physicists*; page 386, line 16 from bottom, read *researchers* for *researches*, page 387, line 11 from top read *Broun* for *Brown*; page 388, line 5 from bottom, for 1850 read 1856; page 390, bottom line, for *manthly* read *monthly*; page 393, fourth line from top, for *maximum* read *minimum*; in eleventh line of page 394 insert *the* after *of*. Sorry that it was impossible to hold type for the authors corrected proof.

BOOK NOTICES.

Hand book of Descriptive and Practical Astronomy, by George F. Chambers, F. R. A. S., Oxford, England, at the Clarendon Press, 1889.

A copy of the first part of the fourth edition of Chambers Handbook of Descriptive and Practical Astronomy has reached our table. American readers of the MESSENGER who have not seen the first part of the new edition of this standard work on astronomy will doubtless be glad to know what changes have been made. The most important of these we will give as fully as space will allow. The fourth edition was a single volume of 928 pages, but there were undesirable omissions in its plan, and so the author went back to the original plan, of three volumes for the entire work as he had arranged the scheme twenty-nine years ago. The three divisions of the present work are as follows:

- I. The Sun, Planets and Comets.
- II. Instruments and Practical Astronomy.
- III. The Starry Heavens.

The intention now is that each volume will be paged, indexed and sold separately.

The most obvious changes in the matter pertaining to the themes of the first part of the fourth edition are the illustrations. In the previous work for the same subjects there were 133 cuts; in this volume we find 253. All data depending on the solar parallax have been re-computed using the value of $8''.80$, and a number of verbal changes, omissions and additions are noticed in the text: for example the extension of the table showing the results of Wolf's sun-spot observations from 1874 to 1887 giving a continuous period of thirty-eight years, the addition of six new cuts showing the appearance of sun-spots observed in 1883 and 1886, and the new and fuller statement pertaining to the photosphere, chromosphere and corona, bringing the study of the sun within the range of most modern investigation.

The introductory chapter on the planets has six new pages of matter with four new cuts, one giving the apparent motions of Mercury and others, the apparent sizes of the planets. The chapter on Vulcan (?) in the new edition is increased by six pages, also much of the matter being in fine

print and containing a fair account of the views and discussions of American astronomers relative to the supposed discovery of Valcan. The planet Mercury is given two new illustrations and a brief account of the recent studies of Denning and Schiaparelli, and mention is also made of Professor Newcomb's view that discordance between the observed and theoretical motions of the perihelion of Mercury's orbit, first pointed out by Le Verrier really exists and is indeed larger than he supposed.

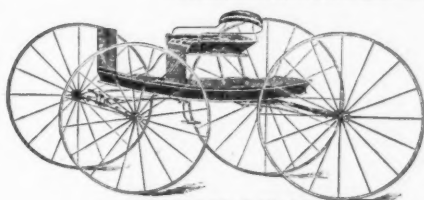
Considerable variation and addition are found in the text for the planet Venus. Six illustrations of phases and spots seen by several observers furnish most of the new matter. Newcomb's mass of the planet, which agrees most nearly with that of Littrow, is given in this edition. The increase of matter in the chapter on the earth is five pages, with an illustration of Foucault's pendulum experiment to show the earth's axial rotation. The description of the experiment is a worthy edition to the former text. In a way quite similar to these particular citations the whole text of this revision is dealt with in regard to the remaining planets. Then follow eclipses and associated phenomena, to which large space is given, followed by chapters on transits of inferior planets, occultations, tides and tidal phenomena, and other general physical phenomena, closing with comets, meteors, and shooting stars. The tables, notes, and illustrations accompanying the last-named themes are varied and full, and close a volume of 676 pages of closely arranged and well ordered matter.

Professor Chambers has made an excellent beginning in the revision of this book, and we shall soon look for the second volume in the series, which is also promised for the autumn of 1889. The third is expected to be completed in 1890.

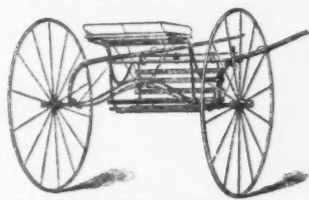
As a closing thought we can not do better than to take his own words from the preface of the last edition. Though not closely connected with the general idea of this review they plainly show how a leading English scholar and scientist looks at some of the broader and greater questions of the present time. He says: "Where are we now in the effort to discover first causes? The answer is: Very much where we were a quarter of a century ago. The theory of evolution may be true, or it may be false, but be it one or the other I agree with Professor Mivart (who believes it) when he says, 'There is no necessary antagonism between the Christian Revelation and Evolution.' Evolution is an attempt to guess at a process; it does not touch the Author of that process and never will."

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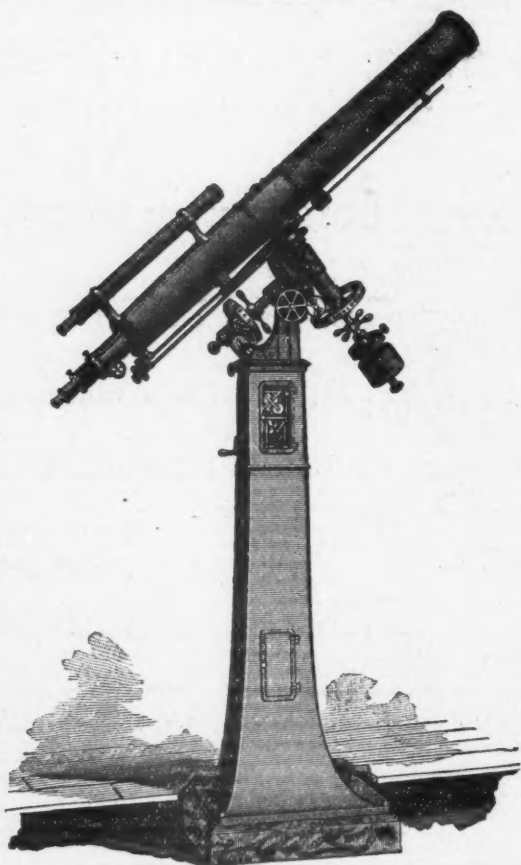
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